

What is claimed is:

1. A method for manufacturing a hollow rack shaft comprising:

a first step for forming a substantially flat and rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and

a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein a surface of a die set used in said first step is inclined in longitudinal direction of said workpiece so as to cancel elastic recovering of said workpiece when said workpiece is removed from said die set.

2. A method for manufacturing a hollow rack shaft comprising:

a first step for forming a substantially flat and

rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and  
a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein a die set used in said second step provides a complementary surface to a row of rack teeth formed on said flat bottom portion and said surface previously provides a shape to cancel elastic recovering of said workpiece when said workpiece is removed from said die set.

3. A die set used in a method for manufacturing a hollow rack shaft, said method comprising;

a first step for forming a substantially flat and rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion

extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and

a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein, a die set used in said second step provides a complementary surface to said semi-circular bottom portion and a surface of said die set is inclined in longitudinal direction of said workpiece so as to cancel elastic recovering of said workpiece when said workpiece is removed from said die set.

4. A die set used in a method for manufacturing a hollow rack shaft, said method comprising;

a first step for forming a substantially flat and rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly

in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and

a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein a die set used in said second step provides a complementary surface to a row of rack teeth formed on said flat bottom portion and said surface previously provides a shape to cancel elastic recovering of said workpiece when said workpiece is removed from said die set.

5. A method for manufacturing a hollow rack shaft comprising:

a first step for forming a substantially flat and rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said

flat bottom portion of said gutter-shaped workpiece; and  
a third step for forming said workpiece into a hollow  
shape by bending said leg-like side walls by butting edges  
of said walls each other;

wherein a surface of a die set used in said second  
step is provided with a plurality of recesses for releasing  
surplus material of said workpiece in a die clearance at  
a stroke end of press-forming.

6. A die set used in a method for manufacturing a  
hollow rack shaft, said method comprising;

a first step for forming a substantially flat and  
rectangular plate workpiece into a gutter-like shaped  
workpiece; said gutter-like shaped workpiece has a flat  
bottom portion, a pair of semi-circular bottom portion  
extending from each longitudinal side of said flat bottom  
portion and a pair of leg-like side wall extending upwardly  
in parallel from each lateral side of said flat bottom portion  
and said semi-circular portions;

a second step for forming a row of rack teeth on said  
flat bottom portion of said gutter-shaped workpiece; and

a third step for forming said workpiece into a hollow  
shape by bending said leg-like side walls by butting edges  
of said walls each other;

wherein, a surface of said die set used in said second step is provided with a plurality of recesses for releasing surplus material of said workpiece in a die clearance at a stroke end of press-forming.

7. A die set according to claim 6, wherein, each die of said die set is divided into a plurality of segments at said recesses.

8. A die set according to claim 7, wherein, said recess is located at a position where a protrusion formed by said recess does not interfere with a pinion engaged with said rack .

9. A die set according to claim 6, wherein, said recess is located at a position where a protrusion formed by said recess does not interfere with a pinion engaged with said rack .

10. A method for manufacturing a hollow rack shaft comprising:

a first step for forming a substantially flat and rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat

bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and

a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein, said second step further comprises a preliminary forming step and a main forming step;

at said preliminary forming step, a row of intermediate rack teeth substantially equal to the finally required pitch and smaller than the finally required pressure angle is formed; and

at said main forming step, a row of rack teeth with required tooth shape is formed.

11. A method according to claim 10, wherein, a surface of said die set used in said main forming step is provided with a plurality of recesses for releasing surplus material of said workpiece in a die clearance at a stroke end; and

each die of said die set is divided into a plurality of segments at said recess.

12. A method for manufacturing a hollow rack shaft comprising:

a first step for forming a substantially flat and rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and

a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein, said third step is executed with inserting a mandrel with a semicircular upper half portion.

13. A mandrel used in a method for manufacturing a hollow rack shaft, said method comprising:

a first step for forming a substantially flat and

rectangular plate workpiece into a gutter-like shaped workpiece; said gutter-like shaped workpiece has a flat bottom portion, a pair of semi-circular bottom portion extending from each longitudinal side of said flat bottom portion and a pair of leg-like side wall extending upwardly in parallel from each lateral side of said flat bottom portion and said semi-circular portions;

a second step for forming a row of rack teeth on said flat bottom portion of said gutter-shaped workpiece; and  
a third step for forming said workpiece into a hollow shape by bending said leg-like side walls by butting edges of said walls each other;

wherein said mandrel is provided with a semicircular upper half portion and is inserted between said leg-like side walls when said third step is executed.

14. A mandrel according to claim 12, wherein said mandrel is divided into two segments or more so that said segments are removed from said hollow rack shaft after said third step is executed.